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MORPHOLOGY OF THE FLOWERING PLANTS.

Morphology of Angiosperms. Part ii. Morphology of Spermatophytes. By J. M. Coulter and C. J. Chamberlain. Pp. x + 348; illustrated. (New York and London: Appleton and Co., 1903.)

DURING the last decade or so the aspects of vegetable morphology have undergone an astonishing change, one indeed almost approaching the nature of a revolution. Many of the controversies of twenty years ago have now ceased to excite interest, and those old standing problems on which attention will always be concentrated have come to be regarded from other standpoints, whilst hosts of new ones have hustled themselves to the front. Several causes have contributed to effect this change in the whole perspective of the science. The introduction of more precise methods of observation and experiment has resulted in the disintegration of more than one cherished superstition, but it has been at the same time fertile in good results by leading to a re-examination of the foundations of our morphological beliefs. Our horizon has been greatly extended by the remarkable advances made in palæontology and cytology, and we have been thus enabled to link together many facts and phenomena the connection of which had hitherto been unsuspected or at the best but guessed at.

Sooner or later the newer points of view come to be reflected in new types of text-books. The volume before us is one of these pioneer works. It makes no pretence of dealing with the whole range of so vast a subject as that of the morphology of angiosperms, but the authors have wisely selected, out of the mass of information at their disposal, such material as may illustrate the main thesis they had in view in writing the book. This thesis might perhaps be fitly described as the angiosperms from a phylogenetic standpoint. The whole treatment converges to this end, including also the somewhat curtailed account of angiospermic anatomy separately contributed by Prof. E. C. Jeffrey.

Naturally the different portions of the work are of unequal value; this is partly to be attributed, as in the case of the later geological evidence, to the comparative exiguity of trustworthy information, and in part also, perhaps, to considerations of space.

The general character of the treatise may be gathered from the headings of the earlier chapters. Thus we find the microsporangium, the megasporangium, the female gametophyte, fertilisation, the endosperm, all receiving a full treatment in separate chapters. Other important phases in the life-history of a typical angiosperm are similarly dealt with, and each phase is treated from a comparative standpoint.

One of the most interesting discussions, at least to an advanced student, is that on the phylogeny of the two main divisions of the angiosperms. The various probabilities are ably put forward and sifted, and after

reviewing the whole, the authors are inclined to consider the dicotyledons as having sprung from a stock distinct from that which gave birth to the monocotyledons. They are inclined to regard the unquestioned similarity in the stages characteristic of the germination of the embryosac, in the two phyla respectively, as being attributable rather to convergence than to community of origin, much in the same way, perhaps, as we now recognise heterospory to have appeared independently in all the advanced groups of vascular cryptogams. But in this instance, as in others in which there is also room for great divergence of opinion, one cannot fail to be struck by the fairness with which they present the evidence, even when it militates against their own particular view.

The angiosperms as a whole are likewise considered to have originated independently of the gymnosperms, in spite of the apparent points of contact exhibited, *e.g.* by the Gnetaceæ in certain of their reproductive structures, with the higher group. The differences are held to be of such moment as to be irreconcilable with any close affinity, and the authors emphasise their position by proposing to retain the term spermatophyte as one of mere convenience, and not as in any way implying near relationship. Probably many will agree with this attitude of caution in the absence of more palæontological evidence than we at present possess, and it is at any rate clear that modern work has sufficed to accentuate the remoteness of the gymnosperms, not only from the dicotyledons with which they were formerly grouped, but from the whole angiospermic class.

It cannot, of course, be expected that all the theoretical interpretations and conclusions advocated by the authors will commend themselves with equal force to other botanists, and we find ourselves unable to follow them in all their proposed modifications of terms. Thus it does not appear to be a substantial gain to limit, even implicitly, the term *dioecious* to the gametophyte. The word is perfectly well understood in connection with the sporophyte, and if we accept (as it seems reasonable to do) their own conclusion that the spore-mother cell is the point at which the sporophyte generation terminates, the term may still serve according to the current use. For if the gametophyte is regarded as being inaugurated on the division of the spore-mother cell, the spores themselves, produced within the tissues of the sporophyte, form an early stage of the sexual generation. This view is based on the important nuclear changes associated with the formation of the spores, and it has already been adopted, at least in this country, as a cardinal point in the life-history of the higher plants. The objection raised against the terms gynæcium and andræcium by reason of their conveying a significance as to sex is quite parallel to the one before mentioned; but no one would regard the term male or female, as applied to an animal, to be incorrectly used on the ground that the sexual elements are the real male and female cells. The matter is not affected by the fact that these tissues are often segregated from the soma at so early a period, and with such definiteness, that many zoologists have concluded that there is a fundamental dis-

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inction between soma and sexual tissues comparable with that which in plants finds its expression in alternation of generations.

On the other hand, the proposal to replace the expression "double fertilisation" by that of "triple fusion" strikes us as a good one. It is by no means certain that the process indicated is really of the nature of fertilisation at all, and until more evidence enables us to form a reasoned opinion as to the meaning of these remarkable phenomena that precede the formation of endosperm in a large number of cases, it is better to avoid taking up, even nominally, what may prove to be a totally untenable position. Indeed, we already know that endosperm may arise, in some instances, independently not only of the addition of the extra male nucleus but also even of the fusion of the two polar nuclei themselves.

It is not possible to discuss the many points raised in this interesting work in any detail. Every serious student of botany will certainly peruse it for himself and can form his own judgment on controversial matters. He will be aided in this by the copious references to literature which form not the least valuable feature of this fine book.

Here and there we note an occasional slip, *e.g.* the suggestion that the investigations which have led to a general disbelief in the occurrence of centrosomes in angiosperms originated in Germany. But as a general rule the statements are remarkably free from inaccuracy. It is not possible to conclude this notice without commenting on the excellent manner in which the book is got up. The text, and especially the illustrations, both in character and execution, are all that could be desired.

J. B. F.

APPLICATIONS OF PHYSICAL CHEMISTRY.

Physical Chemistry in the Service of the Sciences.

By J. H. van 't Hoff. Edited by Prof. Alexander Smith. Pp. xviii + 126. (The University of Chicago Press, 1903.) Price 1.50 dollars.

THIS handsome volume is based on a course of nine lectures delivered in 1902 at Chicago, where Prof. van 't Hoff was the guest of the university; it deals with the extension of Avogadro's law to solutions, and the thermodynamical principle of the conservation of energy; the thermochemical and electrical methods of determining what chemical changes are able to do work, and the theory of ionisation; the application of the phase-rule in relation to the extraction of pure salts from the Stassfurt deposits, and to the metallurgy of iron and steel; osmotic pressure in its physiological applications, and the catalytic action of enzymes; and the nature of the salts deposited by the evaporation of sea-water, and the reasons for their formation. The lecturer has thus, by carefully chosen examples, illustrated the bearing of modern physical chemistry on manufacture, on physiology, and on geology.

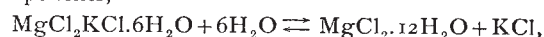
Prof. van 't Hoff tells a curious tale of the celebrated Kekulé, professor at Bonn, who thirty years ago took the pessimistic view that chemistry, as a science, had come to a stand, and that a Newton was necessary

before further advance could be made. It was an unfortunate utterance, for no science has made greater strides within the last quarter of a century, and Prof. van 't Hoff has done much to contribute to its advance. The fortunate conjunction of three men, van 't Hoff with his magnificent powers of generalisation, Arrhenius with his keen insight, and Ostwald with his encyclopædic knowledge and rare gift of exposition, has largely aided the rapid progress of physical chemistry. But the first step was taken by van 't Hoff and Le Bel, in their simultaneously conceived theory of the representation of the molecule in three dimensional space.

In discussing the aid which physical chemistry has given to pure chemistry, the author states:—

"The most recent development of physical chemistry has been characterised rather by the establishment of comprehensive principles which fertilise the whole foundation of the science, and which promise to furnish nourishment for a large part of the chemistry of the future."

A short explanation of the nature and laws of osmotic pressure is then followed by a brief statement of the nature of a reversible cycle and its application to the case of carnallite. The "principle of maximum work" is next considered, and the fallacy contained in it, and the suggestion is thrown out that all thermochemical work should be repeated, "with the object of determining the ability of each reaction to do work." This suggestion is again illustrated by help of carnallite as an instance. At -21° , the temperature of equilibrium between carnallite and its components,



the possibility of doing work is zero. But above this temperature, the reaction can overcome a resistance such as a pressure; hence $dE = -WdT/T$, and a cyclic change is possible. For finite values $E = -W\Delta t/T$; hence, while at the transition temperature where $\Delta t = 0$, $E = 0$, both above and below it the sign of E changes. Of course, at absolute zero, $E = W$, where $\Delta t = -T$, and the heat developed will be a measure of the capacity to do work, and the fact that Berthelot's principle of maximum work holds in many cases is merely due to the temperature of experiment being relatively low—only 273° above absolute zero. At 1000° , on the contrary, acetylene is formed with absorption of heat, and water decomposes in spite of the fact that its formation is accompanied by evolution of heat. This abridgment of van 't Hoff's argument will give an idea of the simple and clear method of statement. In a similar manner the connection of the capacity to do work with electromotive force is explained, and illustrated by the example of a thallium-thallium chloride-potassium thiocyanate cell. Arrhenius's conception of ions is thus introduced and shortly described.

In dealing with the connection between physical and industrial chemistry, van 't Hoff emphasises the circumstance that in Germany the most hearty co-operation exists between manufacture and science, alluding to the fact that it is not there expected that the physical chemists shall give "tips" to the in-